Chapter 10
Arctic Well Construction

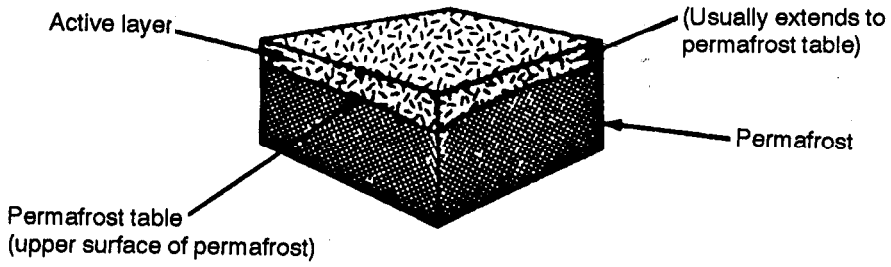
10-1. Considerations.

a. *Arctic Water Supply*. Supplying water for operations or bases in the Arctic and adjacent cold regions requires careful planning due to the harsh climate and ground conditions. Potable water is widespread at the surface in some cold regions but is uncommon in more arid cold regions. Locally, surface water can be melted from ice or pumped from unfrozen lakes or glacial-melt pools. Many surface sources are only dependable during the summer months, leaving potential problems in supplying water throughout the year. More dependable, year-round supplies of groundwater may be developed through wells in relatively shallow, unfrozen strata (Figure 10-1) and from wells that fully penetrate the permafrost.

WARNING

Do not touch cold metal with your bare hands.

Discontinuous Permafrost



Continuous Permafrost

Figure 10-1. Unfrozen strata

Permanently frozen rock and soil are widespread in the Arctic north of 50°N latitude. This condition restricts groundwater development because some of the groundwater is permanently frozen and not available. The frozen zones, which vary in thickness from a few feet to 2,000 feet, are impermeable aquicludes and inhibit the upward movement of unfrozen groundwater. The difficulty of obtaining water increases northward as the permafrost thickens and becomes colder and more continuous.

b. *Discontinuous Permafrost.* In this zone, permafrost will be thin and may be absent on the south slopes of hills, in valley bottoms containing permeable alluvial material (sand and grovel), and under surfaces that have been cleared of vegetation (airport runways, farmlands, forest-fire scars, and logging tracts). Obtain information from local sources regarding springs (icings), existing wells, unfrozen zones, and caves used for storage. Consider obtaining water from surface sources before drilling and developing wells in the permafrost zone. The existence of a good, year-round water source at the surface in the discontinuous zone will indicate that the ground is not frozen beneath the well. Year-round springs, large streams, and lakes can serve as water sources. Even if the water is unpotable, these sources indicate *windows* in the permafrost where dug, driven, jetted, or drilled wells may be located.

Vegetation could indicate the presence and thickness of permafrost. Tree roots rarely exceed a depth of 3 feet. Therefore, the presence of large trees may indicate that only the top of the permafrost during the thawing season is deeper than usual. Large trees along a river could suggest that either the top of the permafrost is depressed to afford a limited supply of water or that permafrost may be absent. The presence of pine or aspen may indicate a similar depression of the permafrost table or possibly the complete absence of permafrost. The presence of willow shrubs (not trees), peat and moss, or stunted tamarack and birches may indicate a thin zone of summer thawing (active zone) and the presence of cold, thick permafrost near the surface. These indicators are more frequent in a thick, continuous permafrost zone.

c. *Thick, Continuous Permafrost.* Generally, you will have to use surface sources when underlain by thick, continuous permafrost. Available groundwater will require drilling deep (several hundred feet) wells through the permafrost. Such a task may be beyond the scope of a military operation.

10-2. Well Drilling.

a. *Drilling Equipment.* You will use the same drilling equipment as for normal well drilling and additional accessories required because of adverse weather conditions. You will need portable gasoline or diesel heaters for personnel and equipment at the construction site. You will also need electrical or oil immersion heaters for storage and settling reservoirs. You should have tents or sheds as protection for personnel from cold winds or storms.

b. *Rotary Drilling.* In permafrost regions, use the rotary-drilling method for deep drilling and large diameter holes and for shallow drilling and small holes. The procedure for rotary drilling in frigid climates is the same as in temperate climates except for temperature requirements of the drilling fluid. In adverse weather conditions (extremely low temperatures and snowstorms), construct shelters to protect the rigs and to maintain comfortable working temperatures.

At temperatures below -20°F, generally no drilling is done. The mud used in rotary drilling should beat near-freezing temperatures when entering the drill stem to prevent thawing and caving

of the hole. When necessary, apply enough heat to the mud to prevent the hole from freezing. Make sure the rig operates continuously to prevent the mud pump and accessories, bits, and casing from freezing during operations. If you must stop operations at night, remove the tools, let ice form, and drill out the ice in the morning. In a finished well, you can use the rotary rig to circulate the water to prevent freezing until you can install a pump.

c. *Jet-Drive Drilling.* This is another method of constructing small wells in cold climates. You can also use this method in warm or discontinuous permafrost. The wells are usually 2 inches in diameter and are drilled to a depth of 200 feet. Use the procedures and equipment described in Chapter 9 to construct the wells.

The equipment is simple and light and consists of small derrick and a small engine with a cathead. You push the pipe into the ground and advance it manually dropping a small weight fastened to a line running over a sheave on the derrick to the cathead. The jet point is made from a reducer, which is ground into a bullet shape and attached to the end of the 2-inch pipe. Drill several 1/4-inch holes above the jet point a distance of 1 to 2 feet. A thaw-line pipe projects a maximum of 2 feet through the head of the drive point.

Pump a water jet through the thaw-line pipe during drilling operations. Suspend the pipe on a simple chain hoist and slowly move the pipe up and down. The thaw-line pipe will penetrate the sediments ahead of the jet point. When the thaw-line pipe is about 2 feet ahead of the jet point, retract the pipe. The casing is driven as far as it will go; repeat the process. Use water no warmer than 40°F in this process. Jet-drive drilling proceeds about three times as fast in permafrost as in thawed ground. See Figure 9-1 (page 9-2) for a rig you can use in Arctic well drilling. Figure 10-2 (page 10-4) shows a jet-drive point you should use with the rig.

For depths of 100 feet or less, one man operating a rig can jet drive about 28 feet per day in frozen ground. If the ground is thawing, the footage per day is reduced. The well can yield 40 gallons of water per minute from a 2-inch well equipped with a suction pump with less than 20 feet drawdown. At a depth of more than 100 feet, jet-drive drilling becomes rather slow and difficult. Therefore, try to limit jet-drive drilling to the southern portions of the permafrost zone.

d. *Drilling Fluids.* The fluid used in drilling through permafrost must remain in a liquid state during drilling operations and must not contaminate possible water sources. You can eliminate possible contamination through pumping. When using mud, try to keep the mud from freezing by adding chemical agents such as aquagel, gel-flake, barite, fibratex, smentex, micatex, and impermex. Be careful during periods of excessive permafrost thawing. The hole could slough during drilling. Do not heat the drilling fluid. An increase in the viscosity of the drilling mud will result in a decrease in mud flow, eventually causing freezing or sticking of the bit.

Brine, as a drilling fluid, is not ideal in permafrost areas because it promotes contamination and excessive thawing. It could corrode the drill string, rig, and pump and cause a skin rash on personnel. Use brine sparingly, when required. In normal water-well drilling, you develop the well by pumping after drilling, which clears the well of brine. A suitable brine solution would be 35 pounds of rock salt mixed with 53 gallons of water. In the Arctic, 100 pounds of rock salt is ample for drilling a 15- to 20-foot hole. (Figure 10-3, page 10-4) shows the specific gravity of drilling fluids when using salt additives in mud-drilling operations.) You must clean drilling equipment after using brine.

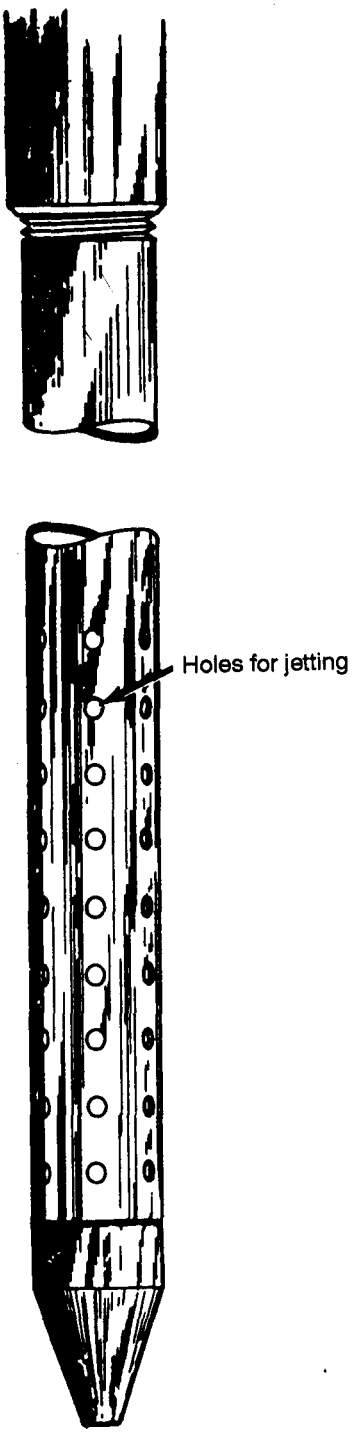


Figure 10-2. Jet-drive point

CAUTION

Adding salts to drilling fluids will reduce the viscosity,

e. *Air Rotary Drilling.* This is the preferred drilling method for intermediate- or large-depth wells if you have the equipment. You do not have to take the same precautions as with rotary drilling.

f. *Well Installation and Completion.* You can use some of the same installation and development methods in cold climates as you did in warm climates, with some precautions. Try to minimize prolonged contact of surface water with any permafrost. Doing so will avoid freezing in the hole or thawing and sloughing the previously frozen wall and the need to redrill. You can use the single-string method to install screen and casing together for wells in rock-like permafrost because disturbance is minimal.

The potential for water freezing after the well starts routine production should be reviewed. You could insulate the well by centering a regular well casing in an oversized drill hole and by packing the annulus with dry sand through the permafrost interval. You could then fit the well for continuous rather than intermittent pumping.

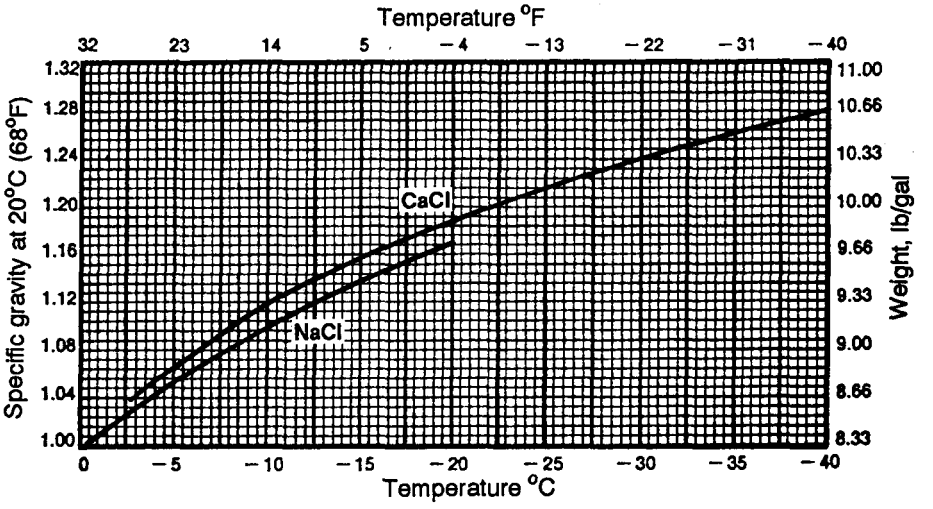


Figure 10-3. Specific gravity of drilling fluids